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(54) Abstract Title
Power tool

(57) A power tool, eg a cordless electric screwdriver, includes a tool carrier (not shown) which may be rotated and driven via a gearing, which is preferably in the form of planetary gearing 10, by a drive motor (not shown), a clutch half 36 within the gearing 10 cooperating with a clutch (not shown) which operates when an adjustable torque is exceeded. The power tool also includes switching means (not shown) which disconnects the drive motor upon a rotation of the clutch half 36 relative to the gear housing 12, detection of the relative movement of the clutch half 36 being effected in a contactless manner, using a sensor 44 connected to an electronic device 48 to send a signal to the switching means. The sensor 44 is preferably fixed in the gear housing 12, and detects the relative rotation of the clutch half 36, the clutch half 36 including a primary detector 52. The sensor 44 may be a Hall-effect sensor, an induction coil or a magnetoresistive sensor, the primary detector 52 in these cases being a permanent magnet (see figure 2). Alternatively, the sensor 44 may comprise a source and a sink of electromagnetic radiation (64,66; figure 3), the primary detector 52 in this case being a series of reflective surfaces (60; figure 3) punctuated by a non-reflective material. Alternatively, the sensor 44 may be an induction coil (72; figure 4), the primary detector 52 in this case being at least one reluctance element (68; figure 4). In addition to these alternatives above, the sensor 44 may also be a piezoelectric, capacitative or inductive element, or a dry-reed switch.

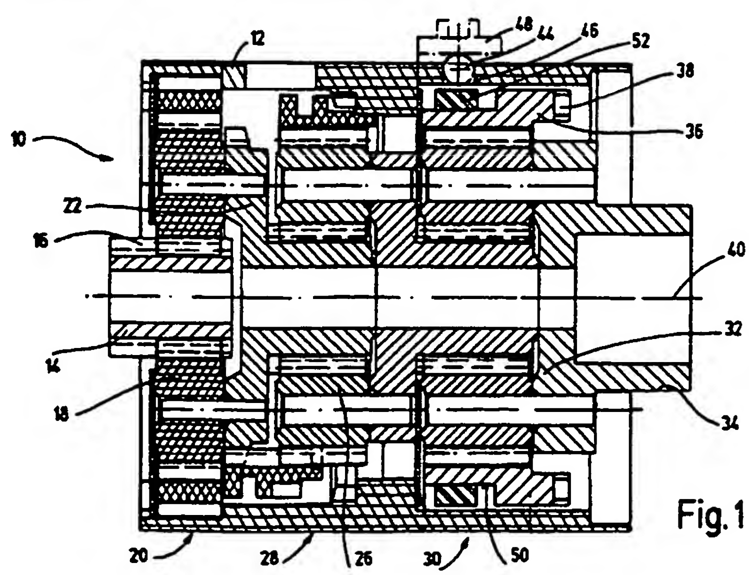

Fig. 1

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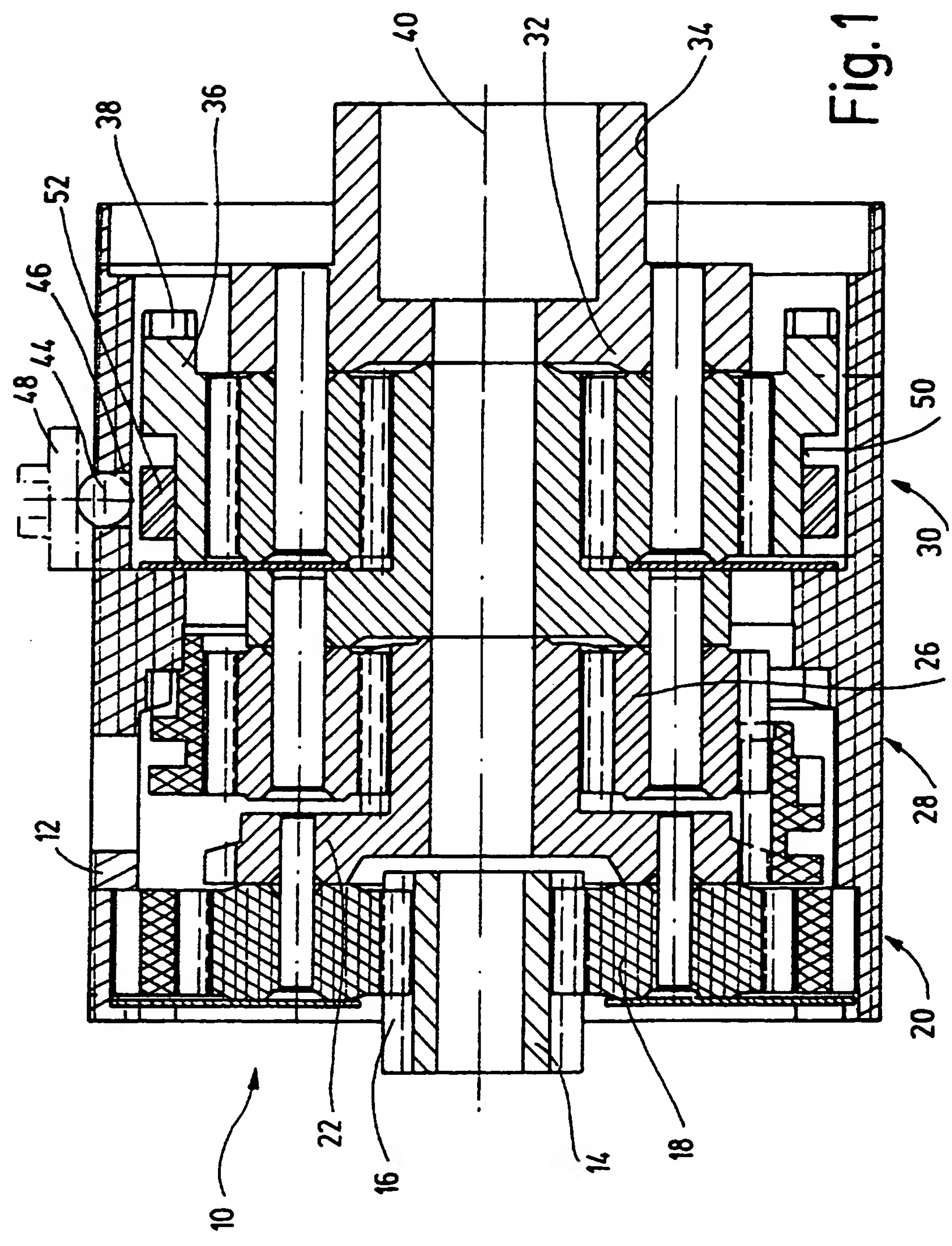
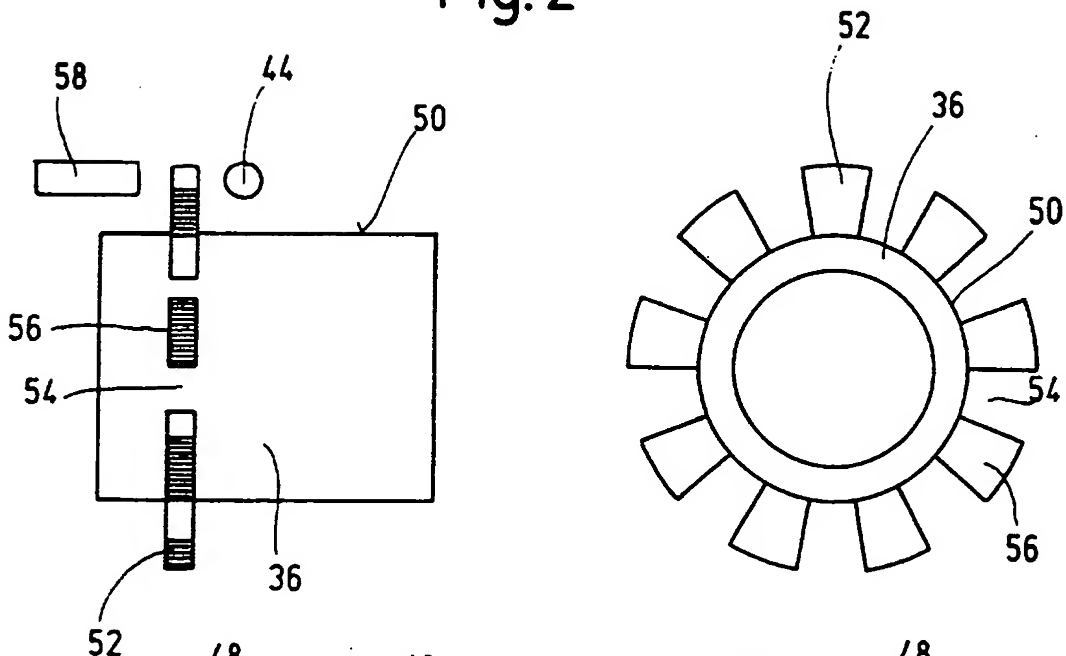


Fig.1

Fig. 2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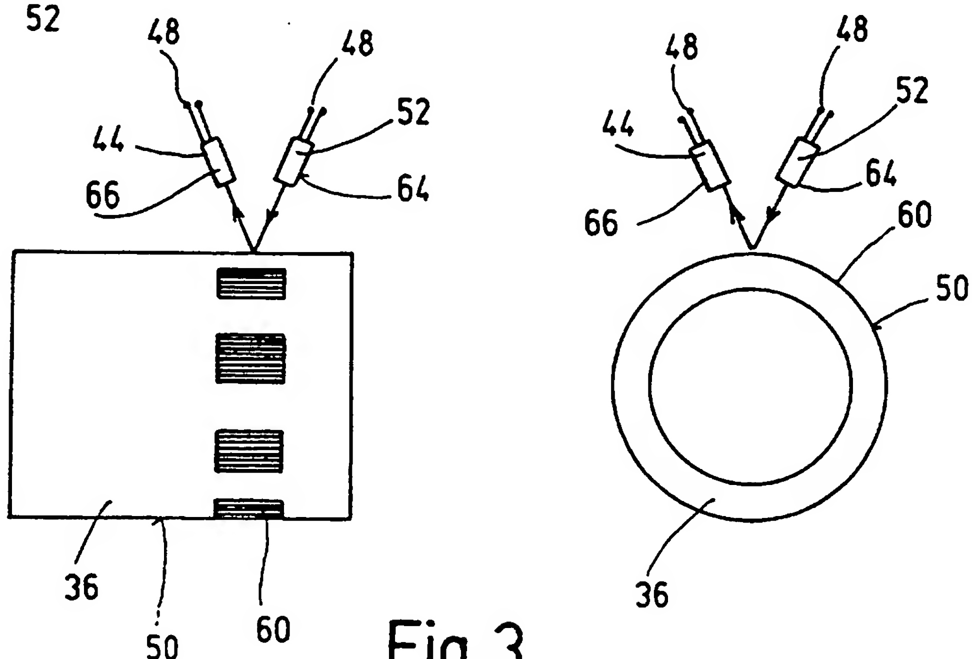
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Fig. 3

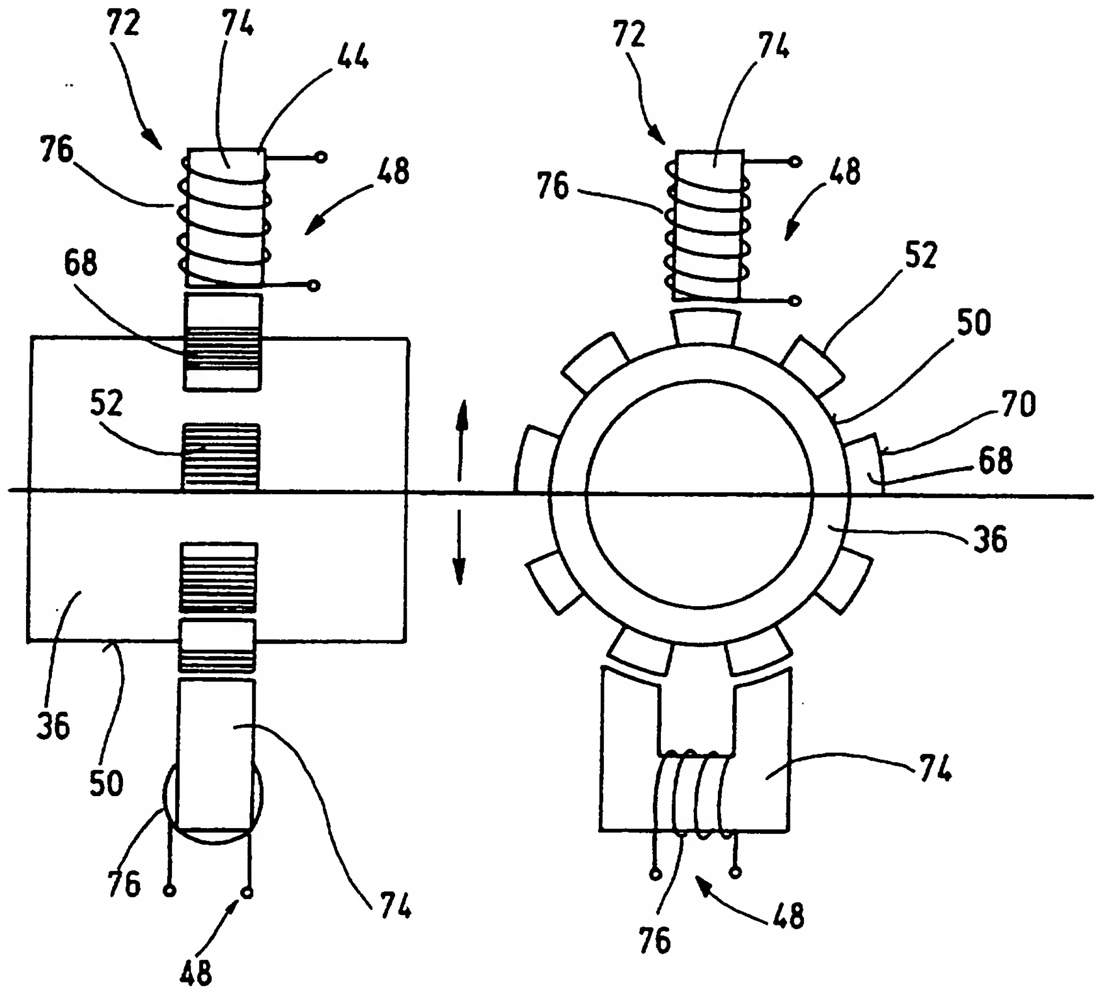

Fig. 4

Tool, in particular a cordless screwdriver

The invention relates to a tool, in particular a cordless screwdriver, with a tool carrier which may be set in rotation, having the features indicated in the preamble of claim 1.

Background art

Tools of the type described are known. Thus, for example, DE 42 43 501 C2 discloses an electric screwdriver comprising a tool carrier, which is drivable via a planetary gearing, a ring gear of the planetary gearing cooperating with a clutch which operates upon attainment of an adjustable torque, and a switching means which disconnects the drive motor upon a rotation of the ring gear relative to a gear housing being triggered as a result of operation of the clutch. The switching means is formed by an electrical contact fastened to the outer periphery of the ring gear and a housing-fixed mating contact, which contacts come into electrically conductive contact upon rotation of the ring gear. The drawback here is that, on the one hand, as a result of mechanically moving contacts a relatively complex design of the switching means is necessary. On the other hand, the contact fastened on the ring gear has to be in electrical contact with a control circuit. This requires a high connection outlay because of the necessary rotatable mounting of the ring gear.

Advantages of the invention

In contrast, the tool according to the invention having the features indicated in claim 1 offers the advantage that an immediate disconnection of the drive motor is effected in a simple manner upon a preselectable torque being exceeded. By

virtue of contactless detection of the relative movement of the clutch half it is possible to dispense with the arrangement of moving mechanical contacts. Thus, detection of a rotation or of an interruption of rotation of the clutch half becomes possible very much more easily and accurately. The rotation of the clutch half which sets in or is interrupted as a result of a preselectable torque being exceeded may be detected immediately, i.e. directly, without a contact distance having to be travelled before the contacting of mechanical contacts. Contactless detection of the rotation of the clutch half moreover enables totally wear-free detection of the relative movement. Thus, even over extended periods of use a reliable, maintenance-free way of disconnecting the drive motor upon a preselectable torque being exceeded is guaranteed.

In a preferred refinement of the invention, it is provided that there is associated with the clutch half a housing-fixed sensor, which detects a physical quantity which is generated or variable as a result of a rotation of the clutch half, the sensor being capable of generating a signal for disconnecting the drive motor. Thus, in a very advantageous manner a rotation or an interruption of the rotation of the clutch half is detectable by means of simple sensors which operate on known principles and may be inexpensively mass-produced, with simultaneous provision of the control signal for disconnection being possible by means of the sensor element. In the present case, both active and passive sensors may be used.

Given the use of active sensors, it is possible in a very advantageous manner to dispense with the provision of a supply voltage for the sensor so that, on the whole, a very simple and inexpensive solution for detecting the speed of the clutch half is possible. As active sensors, use is preferably made of sensors operating on the basis of a piezoelectric effect or electromagnetic induction.

It is further preferred, when passive sensors are used, that said sensors, despite requiring provision of a supply voltage, enable very reliable, highly accurate detection of varying physical quantities which arise as a result of a relative rotation of the clutch half. As passive sensors, use is preferably made of capacitive, resistive, inductive, electromagnetic or optical sensors.

In a further preferred refinement of the invention, it is provided that a primary detector operating the sensors is formed by the clutch half itself. It is therefore possible, optionally by slightly modifying the clutch half, for the latter virtually to signal its own rotation without additional primary detectors having to be provided.

Further preferred refinements of the invention arise from the remaining features indicated in the sub-claims. Thus, the gearing may preferably take the form of planetary gearing, the clutch half being formed by a ring gear of the planetary gearing.

Drawings

There follows a detailed description of embodiments of the invention with reference to the accompanying drawings. The drawings show:

Figure 1 a sectional view through a sub-region of an electric hand tool and

Figures 2-4 various constructional variants of contactless detection of a movement of a ring gear of a planetary gearing.

Description of the embodiments

Figure 1 shows a sectional view through a sub-region of a tool, in particular a cordless screwdriver, which is not shown in its entirety. The tool has a planetary gearing 10 disposed inside a gear housing 12, which is part of an overall tool housing. A drive shaft 14 of a drive motor, generally an electric motor, engages into the planetary gearing 10. A pinion 16 disposed on the driving axle 14 meshes with planet wheels 18 of a first planetary stage 20. The planet wheels 18 are disposed on a carrier 22 having a pinion 24, which meshes with planet wheels 26 of a second planetary stage 28. A third planetary stage 30 is provided in an identical manner. A carrier 32 of the third planetary stage 30 is coupled to a tool carrier 34. The third planetary stage 30 is embraced by a ring gear 36, which is connected by coupling elements 38 to a clutch (not shown). The clutch takes the form of a so-called slipping clutch, which is loadable by means of an adjustable spring element with a variable preloading force. Said adjustable slipping clutch may be used to adjust a torque, which acts upon the tool carrier 34 and leads to a triggering of the slipping clutch. As a result, the ring gear 36 effects a movement relative to the gear housing 12 about a longitudinal axis 40.

As the construction and mode of operation of the planetary gearing 10 as well as the cooperation with the non-illustrated clutch for adjustment of a torque are generally known, no further details thereof are to be provided in the present description. It should also be pointed out that in other embodiments different types of gearing may be used, a clutch half of the slipping clutch being associated in an identical manner with the gearings. In the description, the terms clutch half and ring gear are therefore used synonymously.

Associated with the ring gear 36 is a, here, merely diagrammatically indicated sensor element 44 which may be disposed, for example, in a recess 46 of the gear housing 12. Associated with the sensor element 44 is a, here, likewise merely

indicated electronic device 48 which may be used to provide a control signal for disconnection of the drive motor of the tool. The sensor element 44 detects a relative rotation of the ring gear 36 which arises as a result of operation of the slipping clutch. The detection of said relative movement is effected in the present case in a contactless manner. For operation of the sensor element 44, at least one primary detector 52 may be disposed on the outer periphery 50 of the ring gear 36. To enable detection of even a minute relative movement of the ring gear 36, a plurality of primary detectors 52 are disposed at intervals over the entire outer periphery 50 of the ring gear 36.

General operation is such that the primary detector or detectors 52 signal a relative rotation of the ring gear 36 to the sensor element 44. Said signalling is effected in a contactless manner, i.e. there is no direct touching contact between the ring gear 36 or its primary detector 52 and the sensor element 46. As a result, totally wear-free detection of a relative movement becomes possible without elements which have to be mechanically contacted.

There now follows a description of several concrete embodiments, by means of which the principle of contactless detection of the relative movement of the ring gear 36 is transposable. The intention here is merely to put forward suggestions, without making any claim to completeness. Naturally, further, optionally non-indicated ways of achieving contactless detection of the relative movement of the ring gear 36 are also possible.

Example 1

The primary detector or detectors 52 are formed by permanent magnets, which are

disposed non-rotatably on the ring gear 36 and in the range of movement of which a sensor element 44 in the form of a Hall sensor lies. In a known manner, in an electric conductor, which is situated in a homogeneous magnetic field and in which an electric current flows perpendicular to the magnetic field, a differential voltage is produced perpendicular to the magnetic field and to the flowing current. Said differential voltage may be detected by the electronic device 48 and used to effect a disconnection of the drive motor. For activation of the Hall sensor, it may be provided that in the position of rest of the ring gear 36 there is no permanent magnet 52 disposed opposite the Hall sensor 44. Upon a movement of the ring gear 36 relative to the housing 12 and hence relative to the housing-fixed sensor element 44, the permanent magnet 52 moves into the sensing range of the Hall sensor 44, with the result that the differential voltage is produced. It may further be provided that in the position of rest of the ring gear 36 there is a permanent magnet 52 lying in the sensing field of the Hall sensor 44, with the result that the signal voltage is present. Upon a relative movement of the ring gear 36 the permanent magnet 52 moves outside of the sensing field of the Hall sensor 44, with the result that the signal voltage collapses and so an acceptable control signal is likewise obtainable.

The sensor element 44 may alternatively take the form of an induction coil. A change in the position of the permanent magnet 52 relative to the induction coil induces a voltage which may be picked off as a signal. When the ring gear 36 is in the position of rest, no relative movement between permanent magnet 52 and induction coil occurs, with the result that no signal is present. The induction coil forms an active sensor which does not require its own power supply.

Example 2

In Figure 2, the ring gear 36 is illustrated diagrammatically in a radial and an axial view. Said ring gear 36 on its outer periphery 50 carries, as primary detector 52, a masking disk made of ferromagnetic material which has, over the periphery 50, disc elements 56 alternating with gaps 54. In the region of the masking disk the sensor element 44 is disposed at one side thereof, while a permanent magnet 58 is disposed at the opposite side. The sensor element 44 takes the form of a Hall sensor. Thus, here too there is the possibility, as already described with reference to Example 1, of using a Hall voltage to indicate a relative movement of the ring gear 36. Depending on whether the permanent magnet 58 and Hall sensor 44 arranged opposite one another are separated or not separated by a gap 54 or a disk element 56, the Hall voltage, which is variable thereby, may be used to indicate the relative movement of the ring gear 36.

Example 3

Instead of the Hall sensor as sensor element 44 according to Examples 1 and 2, use is made of a magnetoresistive sensor which alters its resistance in dependence upon an existing magnetic field. Said magnetoresistive sensor may, for example, be incorporated into a resistance measuring bridge (Wheatstone bridge circuit).

Example 4

In Figure 3, the ring gear 36 is once again illustrated diagrammatically in a radial and an axial view. Reflective surfaces 60 are provided over the outer periphery 50 of the ring gear 36. Said reflective surfaces 60 are arranged at intervals, i.e. there is a gap 62 between each two adjacent reflective surfaces 60. The primary detector 52 takes the form of a source 64 of electromagnetic radiation, the light of which strikes the outer periphery 50 of the ring gear 36 in the region of the

provided reflective surfaces 60 at an angle. The sensor element 44 is formed by a sink 66 of electro-magnetic radiation, which is disposed at the same angle to the reflective surfaces 60 as the source 64. Here it is possible to effect either an axial alignment according to the left view shown in Figure 3 or a radial alignment according to the right view shown in Figure 3. The source 64 may be, for example, a light-emitting diode while the sink 66 is, for example, a phototransistor or a photoresistor.

By virtue of such an arrangement it is possible to infer from influencing of the reflection of the light emitted by the source 64 a relative rotation of the ring gear 36. When as a result of the relative rotation of the ring gear 36 a reflective surface 60 moves into the radiation path of the light of the source 64, said light is reflected at the angle of incidence and received by the sink 66. The latter on the basis of the received light generates a control signal, e.g. by means of a light-dependently varying resistance or by means of a switching voltage of a phototransistor.

Instead of reflective surfaces 60 disposed on the ring gear 36 it is possible, according to the arrangement shown in Figure 2, for the ring gear 36 to carry a masking disk made of opaque material, on opposite sides of which the source 64 and the sink 66 are disposed. Thus, in said case also a relative rotation of the ring gear 36 may be detected depending upon the position of the masking disk.

Example 5

In Figure 4, the ring gear 36 is once again illustrated diagrammatically in a radial and axial view. Reluctance elements 68 are disposed as primary detectors 52 over the outer periphery 50 of the ring gear 36. The reluctance elements 68 are

distributed in the manner of an external gearing over the periphery of the ring gear 36. The reluctance elements 68 are made of a magnetically soft, ferromagnetic material. The end faces 70 of the reluctance elements 68 extend preferably along a coaxial peripheral line about the longitudinal axis 40 (Figure 1).

Associated, as sensor element 44, with the reluctance elements 68 is an induction coil 72. The induction coil 72 may take the form of either a bar-type coil, as the top views of Figure 4 reveal, or a U-shaped coil, as the bottom views of Figure 4 reveal. There are therefore two different embodiments illustrated. According to further embodiments, induction coils 72 having more than two end faces directed towards the reluctance elements 68, e.g. E-shaped induction coils 72, are also possible. The induction coils 72 have a coil core 74, which carries a winding 76. The known principle of induction coils is such that, given a varying magnetic flux in the coil core 74, a voltage is induced in the coil 76. A magnetic field in the coil core 74 may be implemented, for example, by the coil core 74 itself being made of a permanent-magnetic material or the magnetic field is generated by the coil 76 itself or by a further coil disposed on the coil core 74. Irrespective of said various constructional variants, a steady state arises in the initial state.

An end face or a plurality of end faces of the coil core 74 directed towards the end faces 70 of the reluctance elements 68 are adapted to the shape of the end faces 70,

i.e. they extend preferably likewise along a coaxial line relative to the longitudinal axis 40.

In the initial state of the ring gear 36, either just one reluctance element 68 or a gap provided between two reluctance elements 68 is associated with the coil core

74. A radial distance of the reluctance elements 68 from the coil core 74 is reduced to a required minimum.

As a result of a relative movement of the ring gear 36, therefore, a reluctance element 68 moves either into or out of the region of the coil core 74. As a result, the magnetic field of the coil core 74 is influenced, i.e. varied. A resultant induction of a voltage in the coil 76 may be evaluated by means of the electronic device 48 and used to provide a signal for disconnection of the electric motor.

Further examples

Besides the described examples, detection of a relative movement of the ring gear 36 is possible by means of a piezoelectric sensor element 44. The latter in a known manner, under the action of an external force, supplies an electric voltage which may be used for evaluation purposes in the electronic device 48. As an external force it is possible to use, for example, an acceleration, pressure, vibration and/or sound-pressure signal caused by a relative movement of the ring gear 36. Thus, here too, contactless detection of the relative movement of the ring gear 36 is possible.

According to further embodiments, a static change of a capacitance and/or a static change of an inductance may be brought about by the variation, caused by the relative movement of the ring gear 36 itself, of physical quantities, e.g. of the acceleration, pressure, vibration and/or sound-pressure signals. By said means signals likewise capable of evaluation are obtained, which via the electronic device 48 trigger a corresponding disconnection of the drive motor of the tool 10.

Finally, the use of a so-called dry-reed switch as sensor element 44 is cited as a

further embodiment. Here, as a result of a relative movement of the ring gear 36 a magnetic field, e.g. produced by a permanent magnet disposed on the ring gear 36, is moved into the effective range of the dry-reed switch, the magnetically soft contact tongues of which consequently close or open so that an electrical signal may likewise be picked off.

What all of said embodiments have in common is that the primary detector 52 disposed on the ring gear 36 may either be formed integrally with the ring gear 36 or additionally attached to the outer periphery 50. When the primary detectors 52 are, for example, permanent magnets, the latter may, for example, be pressed on, glued on or positively attached. A multipole annular magnet may, for example, be disposed over the periphery of the ring gear 36. It is however also possible to attach a plurality of individual magnet poles to a non-magnetic carrier, e.g. a thin plastic film, so that when the carrier is laid on the ring gear 36 the result is practically a magnetic tape formed into an annular magnet.

The reflective surface 60 may be effected, for example, by an alternating arrangement of absorbent and reflective or differently reflective portions or by formation of a surface relief. For example, the reflective surfaces 60 may be achieved in a simple manner by applying a suitable coloration to the outer periphery 50 of the ring gear 36.

Claims

1. Tool, in particular a cordless screwdriver, having a tool carrier, which may be set in rotation and is drivable via a gearing by a drive motor, wherein a clutch half of the gearing cooperates with a clutch which operates when an adjustable torque is exceeded, and having a switching means which disconnects the drive motor upon a rotation of the clutch half relative to a gear housing being triggered or interrupted as a result of operation of the clutch, characterized in that a detection of the relative movement of the clutch half (36) is effected in a contactless manner.

2. Tool according to claim 1, characterized in that associated with the clutch half (36) is a housing-fixed sensor element (44) which detects a physical quantity generated or varied as a result of a rotation or an interrupted rotation of the clutch half (36), the sensor element (44) being capable of producing a signal for disconnection of the drive motor.

3. Tool according to one of the preceding claims, characterized in that the sensor element (44) is an active sensor.

4. Tool according to one of claims 1 to 2, characterized in that the sensor element (44) is a passive sensor.

5. Tool according to one of the preceding claims, characterized in that a primary detector (52) is associated with the sensor element (44).

6. Tool according to one of the preceding claims, characterized in that the primary detector (52) is connected non-rotatably to the clutch half (36).

7. Tool according to one of the preceding claims, characterized in that the primary detector (52) is formed by the clutch half (36) itself.

8. Tool according to one of the preceding claims, characterized in that the primary detector (52) is a permanent magnet and the sensor element (44) is an induction coil.

9. Tool according to one of the preceding claims, characterized in that the primary detector (52) is a permanent magnet and the sensor element (44) is a Hall sensor.

10. Tool according to one of the preceding claims, characterized in that the primary detector (52) is a permanent magnet and the sensor element (44) is a magnetoresistive sensor.

11. Tool according to one of the preceding claims, characterized in that the sensor element (44) comprises a source (64) and a sink (66) of electromagnetic radiation, and for forming the primary detector (52) the ring gear (36) has, for isolating the source (64) with the sink (66), reflective surfaces (60), absorbent surfaces, a surface relief or a masking disk made of material impermeable to the electromagnetic radiation disposed along a peripheral line.

12. Tool according to one of the preceding claims, characterized in that the primary detector (52) is at least one reluctance element (68) and the sensor element (44) is an induction coil (72).

13. Tool according to one of the preceding claims, characterized in that the sensor element (44) is a piezoelectric element.

14. Tool according to one of the preceding claims, characterized in that the sensor element (44) is a capacitive element.

15. Tool according to one of the preceding claims, characterized in that the sensor element (44) is an inductive element.

16. Tool according to one of the preceding claims, characterized in that the sensor element (44) is a dry-reed switch.

17. A tool substantially as herein described with reference to Figures 1 and 2, 1 and 3 or 1 and 4 of the accompanying drawings.

The Patent Office

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Application No:	GB 9817293.5	**Examiner:**	Dr Steve Chadwell
Claims searched:	All	**Date of search:**	26 October 1998

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.P): B3C; B3N

Int Cl (Ed.6): B23B 45/00 47/00; B25B 23/14 23/147

Other: Online: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X,Y	GB 2271522 A	(DESOUTTER) see whole document	X: 1,2,4-7,9,14 Y: 3,8,10,13,15,16
A	GB 2096510 A	(DESOUTTER) Family equivalent: EP 0063460 A2/A3	
Y	US 4671364	(FEIN) see especially figure 3 and column 1 lines 42-49 and claims 3 to 6 Family equivalent: EP 0182986 A1	3,8,10,13,15,16

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
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